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national accelerator laboratory

EXP-73
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ACCELERATOR EXPERIMENT -- Horizontal Tune Variations at F48 as a Function of Radius

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The horizontal tune vs. radius was measured at 8 GeV using 3 bumps to vary the radius in localized areas. The beam is pinged with the E48 pinger. The frequency of a filtered position detector is measured by a H.P. frequency counter, and the rf frequency is measured by a second H.P. counter. A computing plot is used to calculate the fractional tune from the two counters and the harmonic number; the tune is plotted as a function of beam position. One point is plotted per cycle and to facilitate measurement the machine was operated with a .8 sec dc 8-GeV cycle.

The beam was bumped around F48 using a (F46-F48-A11) horizontal bump, and the beam position as plotted in Figure 1 was measured at F48. The electrostatic septum ES40 and 41 wire plane is nominally positioned at +2.5 cm and the beam centroid prior to this experiment was positioned at 0 cm. As can be seen when the beam was moved from +1.3 cm to -2.5 cm the tune changed by .043. Moving the beam from -2.5 cm to -4.5 cm produced only a slight additional rise in tune. When the septum was turned off the tune shift dropped from .043 to .019 between +1.3 cm and -2.5 cm.

In normal operation ES40 and 41 are powered from the same supply. ES41 was removed from the supply and tune vs. radius measured with only ES40 operating at 85 kV. The experiment was then repeated with ES41 at 85 kV and ES40 off. As can be seen from Figure 2, in both cases identical results were obtained. Subsequently both septa were reconnected and run at ½ voltage. Tune vs. radius measurements at ½ voltage gave the same results as running with one septum at full voltage and the other off. This indicates that each septum

affected the beam equally. The septa present during this experiment were of different design, ES40 being the more recent with the cylindrical vacuum chamber and ES41 rectangular. It is also believed that several wires had been removed from ES41, but apparently these differences were not noticed by the beam.

From the change in tune (septum on - septum off) one can calculate the equivalent effective magnetic field gradient required to cause such a $\Delta\nu$:

$$\Delta\nu = \frac{1}{4\pi B_o \rho} \int B' \beta dS \ .$$

Assuming B' is constant over the length of the septa one obtains:

$$B' = \frac{dB}{dr} = \Delta\nu \ \ 61.84 \ \frac{\text{gauss}}{\text{cm}} \ .$$

The graph of B' vs. r can then be integrated across the aperture to obtain the field leakage in equivalent magnetic units which can then be converted to electric field gradient as is plotted in Figure 3. This figure shows that a field approximately equal to 1% of the field in the septum is present at 1 cm away from the wires and it decays to a negligible value at a distance of 4 cm from the wires.

Prior to this experiment the beam was tuned at injection to be 2.5 cm from the wires. This distance was increased to 5 cm following the experiment and the main-ring transmission increased by 6%.

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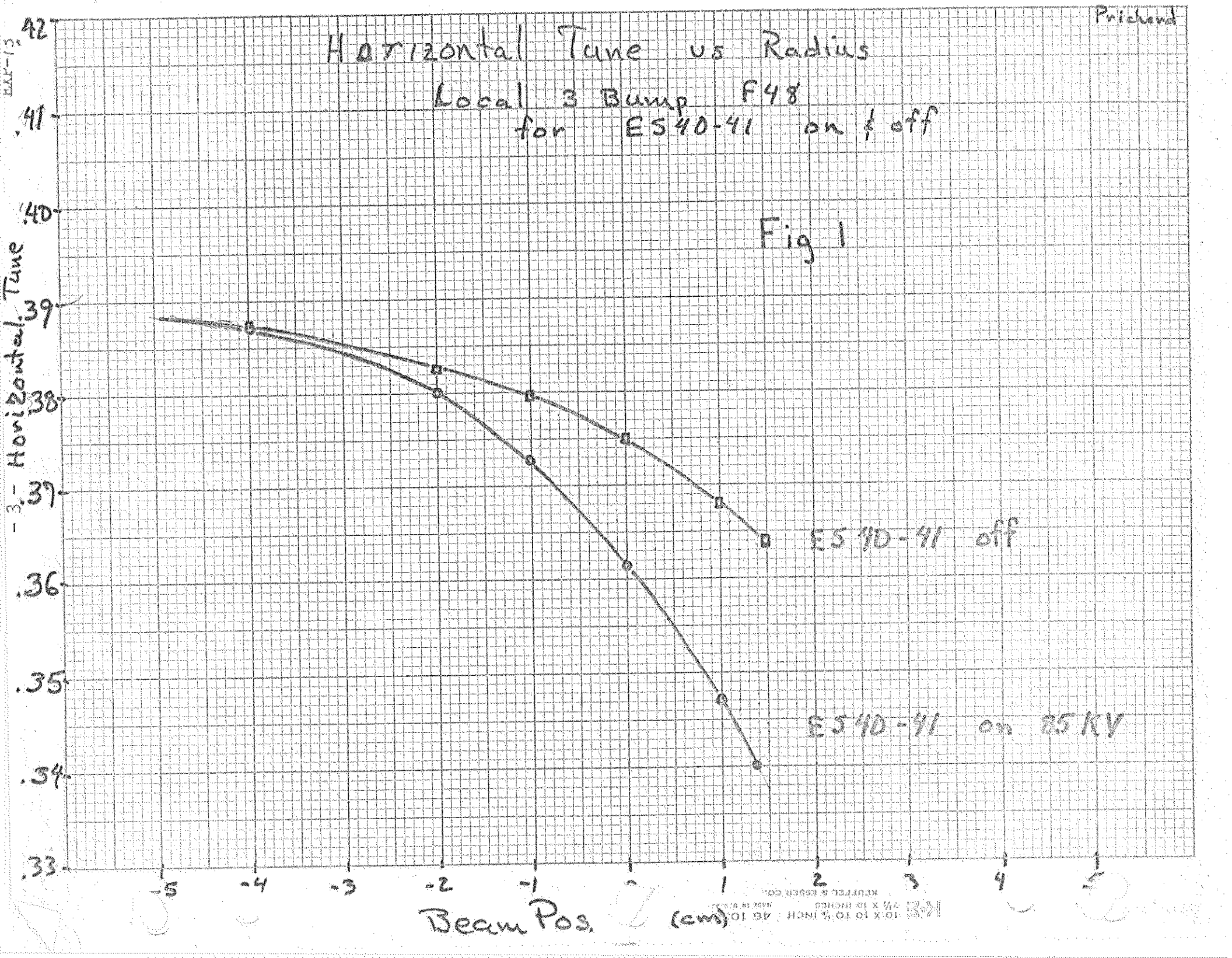
Horizontal Tune vs Radius

Local 3 Bump F48

for ES40-41 on & off

Fig 1



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Electrostatic and Equivalent Magnetic Field Due to E540-41 (85kV) over a length of 20 ft.

Fig 3